Haptic Device Abstraction Layer (HDAL)

API Reference

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Preface

This manual is a reference to the Haptic Device Abstraction Layer produced by Novint Technologies. It contains reference pages to all the HDAL API functions, constants, and types. This manual was current as of the release of the corresponding version of HDAL.

The technical content of this document was mechanically generated from HDAL source code by Doxygen, a general-purpose utility for documenting C and C++ code. For more information on Doxygen, see http://www.doxygen.org.

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Overview

Files

The HDAL API is represented in two files. include\hdl\hdl.h is the primary interface to HDAL's functionality. It is complete, in that entire applications can be built from it. include\hdlu\hdlu.h is a utility interface, presenting functions that may be useful to the developer. HDAL can be used effectively without these utility interface functions.

Units

The units of measure for the HDAL interface are:

Distance	meters
Force	newtons
Time	seconds

The nominal cycle time is approximately one millisecond. However, since operating systems are not able to control intervals with precision adequate to many applications, a more precise time measure may be needed. For precise time calculations, the application should use some precision clock, such as the Windows QueryPerformanceCounter function.

Coordinate Frame

The coordinate system used by HDAL is a right hand coordinate system:

X	increases to the right
Y	increases upward
Z	increases toward the user.

The origin (X = 0, Y = 0, Z = 0) is approximately at the center of the device workspace.

HDAL Reference

include/hdl/hdl.h File Reference

Main API for HDAL services.

```
#include <hdl/hdlExports.h>
#include <hdl/hdlErrors.h>
#include <hdl/hdlConstants.h>
```

Defines

- #define false 0
- #define HDAL_ISREADY 0
  Normal hdlGetStatus return code.

- #define HDAL_NOT_CALIBRATED 0x04
  hdlGetStatus code indicating motors not homed

- #define HDAL_SERVO_NOT_STARTED 0x02
  hdlGetStatus code indicating servo loop net yet started

- #define HDAL_UNINITIALIZED 0x01
  hdlGetStatus code indicating HDAL not yet initialized

- #define HDL_BUTTON_1 0x00000001
  Mask for button 1.

- #define HDL_BUTTON_2 0x00000002
  Mask for button 2.

- #define HDL_BUTTON_3 0x00000004
  Mask for button 3.

- #define HDL_BUTTON_4 0x00000008
  Mask for button 4.

- #define HDL_BUTTON_ANY 0xffffffff
  Mask for any button.

- #define HDL_DEFAULT_DEVICE_ID 0
  ID for the default haptic device (usually one installed).

- #define HDL_INVALID_HANDLE -1
  Handle indicating invalid device handle.

- #define HDL_SERVOOP_CONTINUE 1
  Return code for continuing servo loop.

- #define HDL_SERVOOP_EXIT 0
  Return code for exiting servo loop.

- #define true 1

Typedefs

- typedef unsigned char bool
  define bool type and values for C programmers to use with certain functions

- typedef int HDLDeviceHandle
  Handle to differentiate between multiple installed devices.

- typedef int HDLDeviceID
  ID to differentiate between multiple installed devices.

- typedef int HDLOpHandle
  Type for Servo loop operation handle.

- typedef HDLServoOpExitCode __cdecl HDLServoOp (void *pParam)
  Prototype for Servo operation function.

- typedef int HDLServoOpExitCode
  Type for Servo loop operation exit code.

Functions

- HDLAPI __int64 HDLAPIENTRY HDL_BUILD_VERSION (HDL_VERSION_INFO_TYPE versionInfo)
  Return Build component of version struct.

- HDLAPI int HDLAPIENTRY HDL_MAJOR_VERSION (HDL_VERSION_INFO_TYPE versionInfo)
  Return Major component of version struct.

- HDLAPI int HDLAPIENTRY HDL_MINOR_VERSION (HDL_VERSION_INFO_TYPE versionInfo)
  Return Minor component of version struct.

- HDLAPI int HDLAPIENTRY hdlCountDevices ()
  Count connected devices.

- HDLAPI HDLOpHandle HDLAPIENTRY hdlCreateServoOp (HDLServoOp pServoOp, void *pParam, bool bBlocking)

Schedule an operation (callback) to run in the servo loop.

- HDLAPI void HDLAPIENTRY hdlDestroyServoOp (HDLOpHandle hServoOp)
  Remove an operation (callback) from the servo loop.

- HDLAPI const char *HDLAPIENTRY hdlDeviceModel ()
  Return the device model string.

- HDLAPI void HDLAPIENTRY hdlDeviceWorkspace (double workspaceDimensions[6])
  Retrieve the workspace of the device, measured in meters.

- HDLAPI HDLError HDLAPIENTRY hdlGetError ()
  Return the current error code from the error stack.

- HDLAPI unsigned int HDLAPIENTRY hdlGetState ()
  Query HDAL state.

- HDLAPI bool HDLAPIENTRY hdlGetVersion (HDL_VERSION_REQUEST requestType, HDL_VERSION_INFO_TYPE *versionInfo)
  Get version information.

- HDLAPI HDLDeviceHandle HDLAPIENTRY hdlInitDevice (HDLDeviceID deviceID)
  Initialize a haptic device.

- HDLAPI HDLDeviceHandle HDLAPIENTRY hdlInitIndexedDevice (const int index, const char *configPath)
  Initialize a specific indexed haptic device.

- HDLAPI HDLDeviceHandle HDLAPIENTRY hdlInitNamedDevice (const char *deviceName, const char *configPath)
  Initialize a specific named haptic device.

- HDLAPI void HDLAPIENTRY hdlMakeCurrent (HDLDeviceHandle hHandle)
  Make a specific haptic device current (Allows application to send forces to a specific device).

- HDLAPI void HDLAPIENTRY hdlSetToolForce (double force[3])
  Set the force to be generated by the device, measured in newtons.

- HDLAPI void HDLAPIENTRY hdlStart ()
  Start servo and all haptic devices.

- HDLAPI void HDLAPIENTRY hdlStop ()
  Stop servo and all haptic devices.

- HDLAPI void HDLAPIENTRY hdlToolButton (bool *pButton)

Return current state of tool button(s).

- HDLAPI void HDLAPIENTRY hdlToolButtons (int *pButton)
  Return current state of tool buttons.

- HDLAPI void HDLAPIENTRY hdlToolPosition (double position[3])
  Return current tool position.

- HDLAPI void HDLAPIENTRY hdlUninitDevice (HDLDeviceHandle hHandle)
  Uninitializes a haptic device.

Detailed Description

Main API for HDAL services.

Haptic Device Abstraction Layer Low level, cross-platform, general purpose interface.

Definition in file hdl.h.

Typedef Documentation

typedef int HDLDeviceHandle

Handle to differentiate between multiple installed devices.

Handle is an abstraction returned by the initialization routine.

Definition at line 46 of file hdl.h.typedef HDLServoOpExitCode __cdecl HDLServoOp(void *pParam)

Prototype for Servo operation function.

Parameters:

pParam Pointer to data required by operation

Returns:

Exit code

Errors: None

Definition at line 403 of file hdl.h.

Function Documentation

HDLAPI __int64 HDLAPIENTRY HDL_BUILD_VERSION (HDL_VERSION_INFO_TYPE *versionInfo*)

Return Build component of version struct.

Parameters:

versionInfo HDL_VERSION_INFO_TYPE struct returned from hdlGetVersion()

Returns:

Build component

See also:
hdlGetVersion().
Errors: None.

HDLAPI int HDLAPIENTRY HDL_MAJOR_VERSION (HDL_VERSION_INFO_TYPE *versionInfo*)

Return Major component of version struct.

Parameters:
versionInfo HDL_VERSION_INFO_TYPE struct returned from hdlGetVersion()

Returns:
Major component

See also:
hdlGetVersion(). Errors: None.

HDLAPI int HDLAPIENTRY HDL_MINOR_VERSION (HDL_VERSION_INFO_TYPE *versionInfo*)

Return Minor component of version struct.

Parameters:
versionInfo HDL_VERSION_INFO_TYPE struct returned from hdlGetVersion()

Returns:
Minor component

See also:
hdlGetVersion().
Errors: None.

HDLAPI int HDLAPIENTRY hdlCountDevices ()

Count connected devices.

Parameters:
None

Returns:
Number of connected devices
Errors: None

Note:
Only valid for Novint Falcon devices

HDLAPI HDLOpHandle HDLAPIENTRY hdlCreateServoOp (HDLServoOp *pServoOp*, void * *pParam*, bool *bBlocking*)

Schedule an operation (callback) to run in the servo loop.

Operation is either blocking (client waits until completion) or non-blocking (client continues execution).

Parameters:
pServoOp Pointer to servo operation function
pParam Pointer to data for servo operation function
bBlocking Flag to indicate whether servo loop blocks

Returns:

Handle to servo operation entry
Errors: None

See also:

hdlDestroyServoOp, hdlInitNamedDevice, hdlInitIndexedDevice

HDLAPI void HDLAPIENTRY hdlDestroyServoOp (HDLOpHandle *hServoOp*)

Remove an operation (callback) from the servo loop.

Parameters:

hServoOp Handle to servo op to remove

Returns:

Nothing
Errors: None.

Note:

hdlDestroyServoOp() should be called at application termination time for any servo operation that was added with bBlocking = false.

See also:

hdlCreateServoOp, hdlInitNamedDevice, hdlIndexedDevice

HDLAPI const char* HDLAPIENTRY hdlDeviceModel ()

Return the device model string.

Parameters:

None

Returns:

Device model string
Errors: None

HDLAPI void HDLAPIENTRY hdlDeviceWorkspace (double *workspaceDimensions*[6])

Retrieve the workspace of the device, measured in meters.

Call this function to retrieve the workspace of the current device. Since not all devices have the same physical workspace dimensions, the application must account for different device workspaces. The workspace is defined in the device reference coordinate frame. It is up to the user to transform positions in this coordinate frame into the application's coordinate frame. See hdluGenerateHapticToAppWorkspaceTransform for a utility function to assist in this.

Dimension order: minx, miny, minz, maxx, maxy, maxy (left, bottom, far, right, top, near)

(minx, miny, minz) are the coordinates of the left-bottom-far corner of the device workspace.

(maxx, maxy, maxz) are the coordinates of the right-top-near corner of the device workspace.

Parameters:

workspaceDimensions See explanation above.

Returns:

Nothing
Errors:

- manufacturer specific

- no current device

HDLAPI HDLError HDLAPIENTRY hdlGetError ()

Return the current error code from the error stack.

Returns:

Error code on the top of the error stack.
HDL_NO_ERROR if the error stack is empty.

HDLAPI unsigned int HDLAPIENTRY hdlGetState ()

Query HDAL state.

Parameters:

None

Returns:

Nothing
Errors: manufacturer specific

Note:

If return == HDAL_ISREADY, device is ready. Otherwise, test to see reason:
return && XXXX != 0, where XXXX is
HDAL_UNINITIALIZED hdlInitNamedDevice failed earlier
HDAL_SERVO_NOT_STARTED hdlStart() not called earlier
HDAL_NOT_CALIBRATED needs autocalibration

HDLAPI bool HDLAPIENTRY hdlGetVersion (HDL_VERSION_REQUEST *requestType*, HDL_VERSION_INFO_TYPE * *versionInfo*)

Get version information.

Parameters:

requestType Type of version information requested
versionInfo Requested info

Returns:

Success or failure
Errors: None.
Typical usage:

```
HDL_VERSION_INFO_TYPE deviceVersion;
int                   deviceMajor;
int                   deviceMinor;
__int64               deviceSerialNumber;
if (hdlGetVersion(HDL_DEVICE, &deviceVersion))
{
    deviceMajor = HDL_MAJOR_VERSION(deviceVersion);
    deviceMinor = HDL_MINOR_VERSION(deviceVersion);
    deviceSerialNumber = HDL_BUILD_VERSION(deviceVersion);
}
```

HDLAPI HDLDeviceHandle HDLAPIENTRY hdlInitDevice (HDLDeviceID *deviceID*)

Initialize a haptic device.

Parameters:

deviceID ID of haptic device

Returns:

Handle to haptic device

Errors:

- manufacturer specific
- could not load device specific dll

Deprecated:

Only supports a single device, deviceID is ignored. Included to support older apps. Use hdlInitNamedDevice instead.

See also:

hdlInitNamedDevice

HDLAPI HDLDeviceHandle HDLAPIENTRY hdlInitIndexedDevice (const int *index*, const char * *configPath*)

Initialize a specific indexed haptic device.

Parameters:

index Index of haptic device.

configPath Path/file for ini file.

configPath search order:

See also:

hdlInitNamedDevice

Returns:

Handle to haptic device

Errors:

- manufacturer specific
- could not load device specific dll

Note:

- Support only Falcon devices via index
- Index refers to alphabetical sort order by serial number

Setup sequence:

```
m = hdlCountDevices();
hdlInitIndexedDevice(n); // 0 <= n < m
hdlStart();
hdlCreateServoOp(...);
```

Teardown sequence:

```
hdlDestroyServoOp(...);
hdlStop();
hdlUninitDevice(...);
```

See also:

hdlInitNamedDevice, hdlStart, hdlStop, hdlCreateServoOp, hdlDestroyServoOp, hdlUninitDevice

Note:

In C++ programs, configPath is optional, with a default value of (const char *) 0.

C programs must pass (const char *) 0 to use default configPath

HDLAPI HDLDeviceHandle HDLAPIENTRY hdlInitNamedDevice (const char * *deviceName*, const char * *configPath*)

Initialize a specific named haptic device.

Parameters:

deviceName Name of haptic device.
configPath Path/file for ini file.
configPath search order:

1. relative to executable directory
2. relative to executable directory's parent if executable directory is Debug or Release
3. config directory in path specified by NOVINT_DEVICE_SUPPORT

Returns:

Handle to haptic device
Errors:

- manufacturer specific
- could not load device specific dll

Note:

- Support multiple devices via deviceName string.

Setup sequence:

```
hdlInitNamedDevice(...);
hdlStart();
hdlCreateServoOp(...);
```

Teardown sequence:

```
hdlDestroyServoOp(...);
hdlStop();
hdlUninitDevice(...);
```

See also:

hdlInitIndexedDevice, hdlStart, hdlStop, hdlCreateServoOp, hdlDestroyServoOp, hdlUninitDevice

Note:

In C++ programs, configPath is optional, with a default value of (const char *) 0.
C programs must pass (const char *) 0 to use default configPath

HDLAPI void HDLAPIENTRY hdlMakeCurrent (HDLDeviceHandle *hHandle*)

Make a specific haptic device current (Allows application to send forces to a specific device).

Parameters:

hHandle Haptic device handle

Returns:

Nothing
Errors:

- manufacturer specific
- hHandle invalid

HDLAPI void HDLAPIENTRY hdlSetToolForce (double *force*[3])

Set the force to be generated by the device, measured in newtons.

Forces are in device coordinates. Dimension order: x, y, z

Parameters:

force Measured in Newtons; x, y, z order

Returns:

Nothing
Errors:

- manufacturer specific
- no current device

- max force exceeded

HDLAPI void HDLAPIENTRY hdlStart ()

Start servo and all haptic devices.

Parameters:

None

Returns:

Handle to haptic device
Errors:

- manufacturer specific
- servo could not start

Note:

Starts servo and all haptic devices. Call after all devices are initialized. Start is separated from hdlInitNamedDevice to allow all devices to be initialized before servo operations are started. Currently, only one Falcon at a time is supported, but this restriction will be lifted in the future. Other device types supported by HDAL may already allow multiple devices to be connected.

See also:

hdlStop, hdlInitNamedDevice, hdlInitIndexedDevice

HDLAPI void HDLAPIENTRY hdlStop ()

Stop servo and all haptic devices.

Parameters:

None

Returns:

Nothing

See also:

hdlStart, hdlInitNamedDevice, hdlInitIndexedDevice

HDLAPI void HDLAPIENTRY hdlToolButton (bool * *pButton*)

Return current state of tool button(s).

For multi-button devices, if any button is pressed, pButton* is set to true.

Parameters:

pButton Pointer to bool to hold button state

Returns:

Nothing
Errors: None

HDLAPI void HDLAPIENTRY hdlToolButtons (int * *pButton*)

Return current state of tool buttons.

Returned value is a bitmask of buttons, with the least significant bit associated with button "0".

Parameters:

pButton Pointer to an int to hold button states

Returns:
Nothing
Errors: None

HDLAPI void HDLAPIENTRY hdlToolPosition (double *position*[3])

Return current tool position.

Parameters:
position In x, y, z order, measured in meters.

Returns:
Nothing
Errors: None

HDLAPI void HDLAPIENTRY hdlUninitDevice (HDLDeviceHandle *hHandle*)

Uninitializes a haptic device.

Parameters:
hHandle Handle of haptic device

Returns:
Nothing
Errors: manufacturer specific

See also:
hdlInitNamedDevice, hdlInitIndexedDevice

include/hdl/hdlConstants.h File Reference

Constants for HDAL.

Defines

- #define HDL_VERSION_INVALID -1
  vesion is invalid

- #define HDL_VERSION_NOT_APPLICABLE -2
  version field not applicable

- #define HDL_VERSION_UNAVAILABLE -3
  version field not available

Typedefs

- typedef __int64 HDL_VERSION_INFO_TYPE
  Structure returned by hdlGetVersion.

Enumerations

- enum HDL_VERSION_REQUEST { HDL_HDAL = 0x11, HDL_DEVICE = 0x21, HDL_DEVICE_SDK = 0x22, HDL_DEVICE_COMMS = 0x23, HDL_DEVICE_OS = 0x24, HDL_GRIP = 0x33 }
  Enumeration of version request types.

Detailed Description

Constants for HDAL.

Definition in file hdlConstants.h.

Typedef Documentation

typedef __int64 HDL_VERSION_INFO_TYPE

Structure returned by hdlGetVersion.

See also:
hdlGetVersion

Definition at line 39 of file hdlConstants.h.

Enumeration Type Documentation

enum HDL_VERSION_REQUEST

Enumeration of version request types.

See also:
hdlGetVersion

Enumerator:

HDL_HDAL version of HDAL

HDL_DEVICE device hardware in current device context

HDL_DEVICE_SDK SDK version of current device.

HDL_DEVICE_COMMS communications version of current device

HDL_DEVICE_OS version of device OS

HDL_GRIP grip in current device context

Definition at line 22 of file hdlConstants.h.

include/hdl/hdlErrors.h File Reference

Error codes returned from HDAL.

Defines

- #define HDL_ERROR_INIT_FAILED 0x10
  Device initialization error.

- #define HDL_ERROR_INTERNAL 0x02
  HDAL internal error>.

- #define HDL_ERROR_STACK_OVERFLOW 0x01
  Overflow of error stack.

- #define HDL_INIT_DEVICE_ALREADY_INITED 0x16
  Device already initialized.

- #define HDL_INIT_DEVICE_FAILURE 0x15
  Failed to initilize device.

- #define HDL_INIT_DEVICE_NOT_CONNECTED 0x17
  Requested device not connected.

- #define HDL_INIT_DLL_LOAD_ERROR 0x14
  Could not load driver DLL.

- #define HDL_INIT_ERROR_MASK 0x1F
  Mask for all initialization errors.

- #define HDL_INIT_INI_DLL_STRING_NOT_FOUND 0x12
  No DLL name in configuration file.

- #define HDL_INIT_INI_MANUFACTURER_NAME_STRING_NOT_FOUND 0x13
  No MANUFACTURER_NAME value in configuration file.

- #define HDL_INIT_INI_NOT_FOUND 0x11
  Could not find configuration file.

- #define HDL_NO_ERROR 0x0
  No errors on error stack.

- #define HDL_SERVO_START_ERROR 0x18
  Could not start servo thread.

Typedefs

- typedef int HDLError
  HDAL API Errors.

Detailed Description

Error codes returned from HDAL.

Definition in file hdlErrors.h.

Typedef Documentation

typedef int HDLError

HDAL API Errors.

Client application queries HDAL errors using hdlGetError(). hdlGetError() returns an error type.

Definition at line 19 of file hdlErrors.h.

include/hdlu/hdlu.h File Reference

Utility functions for HDAL applications.

```
#include <hdl/hdlExports.h>
```

Functions

- HDLAPI void HDLAPIENTRY hdluGenerateHapticToAppWorkspaceTransform (double hapticWorkspace[6], double gameWorkspace[6], bool useUniformScale, double tranformMat[16])
  Generate transform for mapping between haptic and game workspace.

- HDLAPI double hdluGetSystemTime (void)
  Compute a precise time based on CPU high performance timer.

Detailed Description

Utility functions for HDAL applications.

Haptic Device Abstraction Layer Low level, cross-platform, general purpose interface.

Definition in file hdlu.h.

Function Documentation

HDLAPI void HDLAPIENTRY hdluGenerateHapticToAppWorkspaceTransform (double *hapticWorkspace*[6], double *gameWorkspace*[6], bool *useUniformScale*, double *tranformMat*[16])

Generate transform for mapping between haptic and game workspace.

Inputs specify the minimum and maximum coordinate values of rectangular paralleliped bounding boxes, measured in meters. The function computes and returns (in transformMat) the transform matrix that will convert the device position into workspace coordinates. See hdlDeviceWorkspace for the HDAL function to retrieve the device's workspace.

Parameters:

hapticWorkspace minx, miny, minz, maxx, maxy, maxz
gameWorkspace minx, miny, minz, maxx, maxy, maxz
useUniformScale If true, scale uniformly across the workspace
tranformMat Transformation from haptic to game workspace

Returns:

Nothing

Errors: None

HDLAPI double hdluGetSystemTime (void)

Compute a precise time based on CPU high performance timer.

Parameters:

None

Returns:

Current system time, in seconds from start of epoch

HDAL API Page Documentation

Deprecated List

Member hdlInitDevice

Only supports a single device, deviceID is ignored. Included to support older apps. Use hdlInitNamedDevice instead.

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